TDC (tomo density control) and how it works

As in all AEC (automatic exposure control) techniques the generator sets a **density voltage** according to
- the chamber type
- the kV value
- the FSC = film-screen-combination (using cassettes, imaging plates or digital detectors) or the image intensifier.

This **density voltage** should be achieved during the exposure.

It is coming in via the Amplimat input plugs EZX 21/22/31/32/41 of the generator, controlled by "dose rate control" which is physically located on-board of CU EZ139.

For AEC falling load or kV-fixed current the dose signal will more (fixed current) or less (falling load) be constant until the dose ramp reached the density voltage setpoint value and the exposure is terminated.
The resulting exposure time is determined by the patient size and of course the application.

At TDC the density voltage setpoint is known by the exposure parameters and the FSC.
The exposure time is always fixed depending on the time which is assigned to various trajectories.

APR data for TDC have to be set according to the sensitivity of the film-screen-combination similar to the APR settings for straight Bucky use.
The average mAs value of the application and patients sizes must be programmed, the mA value with which the exposure will be started is calculated by the generator.
During the exposure dose rate control tries to drive an emission current to achieve a dose ramp which is almost linear throughout the exposure.
At the end of the tomo exposure time (fixed) the density setpoint value should be achieved.

If exposure parameters are not exactly known one can easily set them during an examination:
Tomo series are typically started with a Bucky exposure.
Bucky and tomo RGDV chambers are the same, the selected FSC data set will also be the same.
Multiply the post indication mAs value of the Bucky exposure with 1.2 …1.4 to set the start mA or mAs value for the tomo exposure.

The advantage of TDC is that if the first tomo sweep has been carried out with parameters far out of range finally the second exposure will get the customer a perfect tomo exposure with a linear dose throughout the exposure (as long as he does not push the APR button which will get him the default data set again).

The following pages show all data, details and their explanations one can see during TDC operation of a tomo system hooked up to an Optimus.
A Bucky TH2 system with sensing was used in this case, but it can be any geometry.

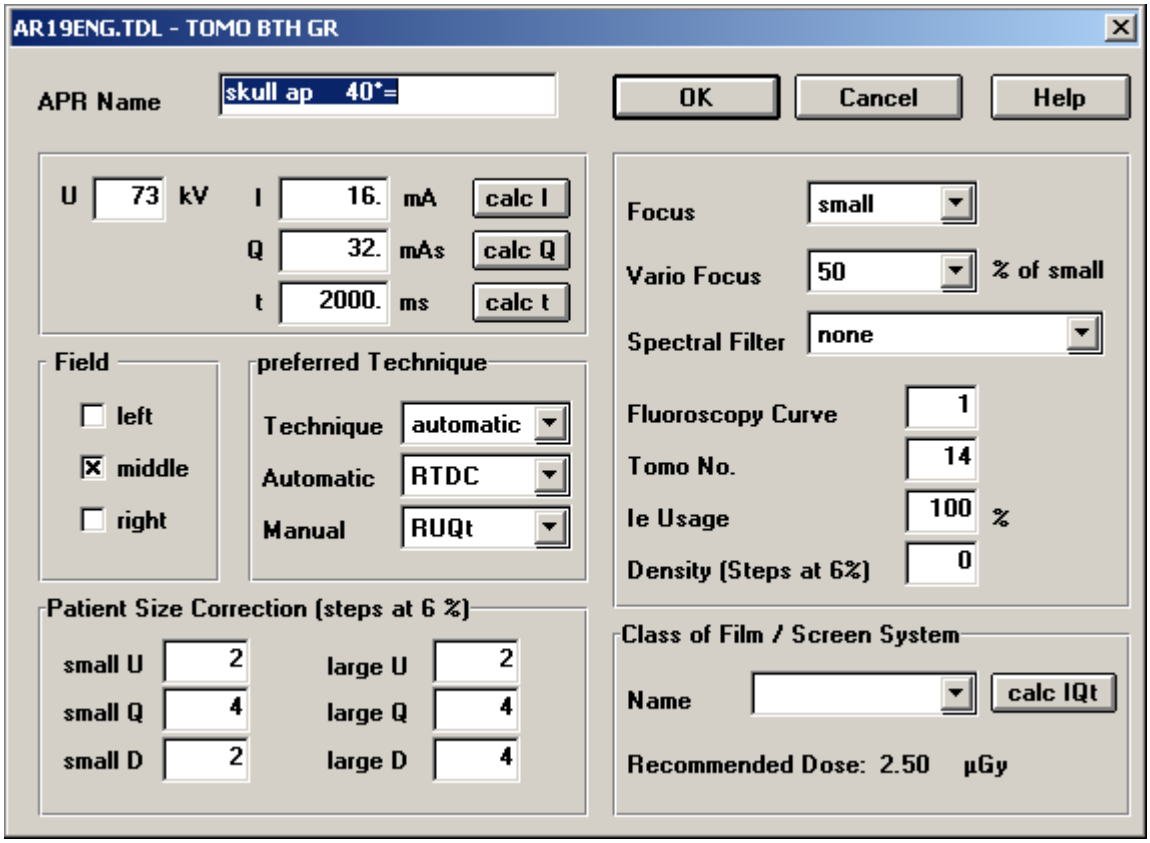
A series of 10 TDC exposures has been carried out with properly preset TDC APR and start values out of range to show the abilities of TDC.

Oscilloscope screenshots shall clarify what happens in the generator and what one can see as result in the form of a dose signal.

Basic test conditions:

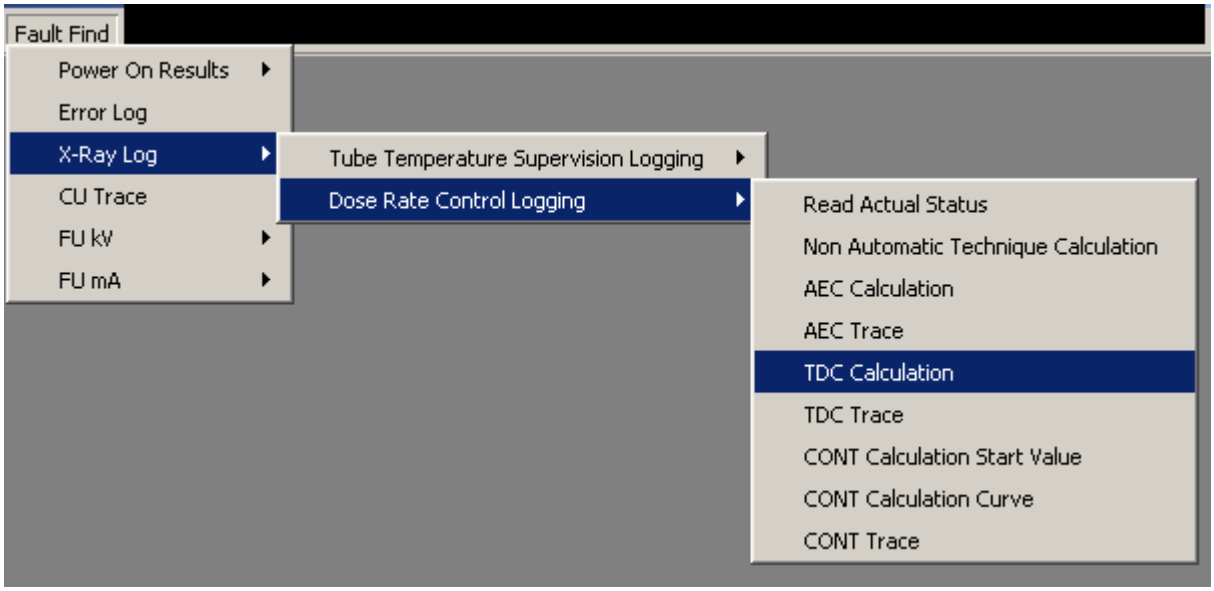
Optimus RAD 80kW with SRO33100 tube
110cm SID
40° tomo sweep 2000ms
collimator opening size 15x15cm, only center field of Amplimat chamber 9890 000 01615
50mm Al filter at the collimator.

A random APR



was selected.

To see what **density voltage** and other TDC relevant parameters one should expect, select path:



TDC initial APR Calculation
Fr 11. Mrz 07:58:45 2005

U nominal	**: 73 kV**
I start	**: 16 mA**
t backup	**: 2000 ms**
C eff ht	**: 4.550 nF**
dose measurement input	**: EZX21**
film screen comb.	**: 1**
dose nominal	**: 1 OD**
I max	**: 410.958 mA**
I min	**: 1 mA**
I max NOMO	**: 234.109 mA**
dose calculated	**: 322**
kV factor	**: 0.960**
U off	**: 0.785 V**
t corrected	**: 1994.811 ms**
number of steps	**: 49**
time/sample	**: 40.710 ms**

Explanation of the calculation screen:

U nominal kV setpoint = 73kV

I start emission current start value; in this case calculated by the selected manual technique RUQt (radiographic kV-mAs-ms) – setpoint 32mAs and 2000ms = 16mA

t backup time at which CU is finally terminating the exposure if DRC (dose rate control) didn't

C eff ht programmed cable capacity (length dependent) and HT transformer capacity; determines the exposure termination kV and load dependent to pass the 75% high tension within the exposure time set during kV discharge
t corrected (next page) is the calculated high tension off command time

dose measurement input physical input plug of the dose sensor

film screen comb. one out of five possible FSC data sets

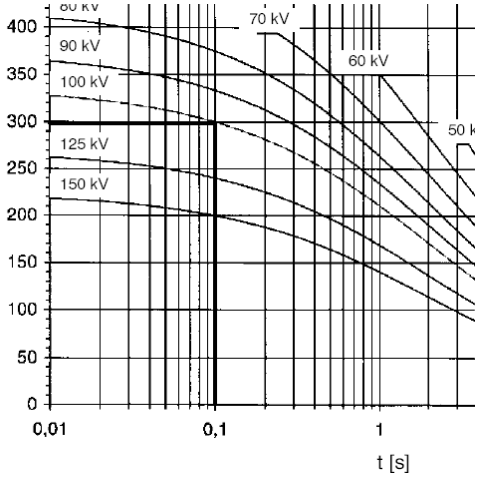
dose nominal indicates the density correction value with + or – correction; 1.00 without correction

"dose nominal : xx **OD"** optical density correction values at 12.5% steps programmed								
- 4	- 3	- 2	- 1	no	+ 1	+ 2	+ 3	+ 4
0.63	0.71	0.8	0.9	1	1.1	1.25	1.4	1.6

I max max emission current kV dependent of the selected focus (might be limited by the max emission current of the generator e.g. 650mA Optimus 50)

I min smallest possible emission current, always 1mA

I max NOMO if the exposure would be set non-AEC in kV-mAs-ms or kV-ma-ms technique the max emission current in this case is 234.109mA for 2000ms at 73kV



dose calculated DRC calculation parameter (value without dimension calculated from the FSC speed)

kV factor kV correction factor relative to 70kV (determined by the chamber and screen characteristic)

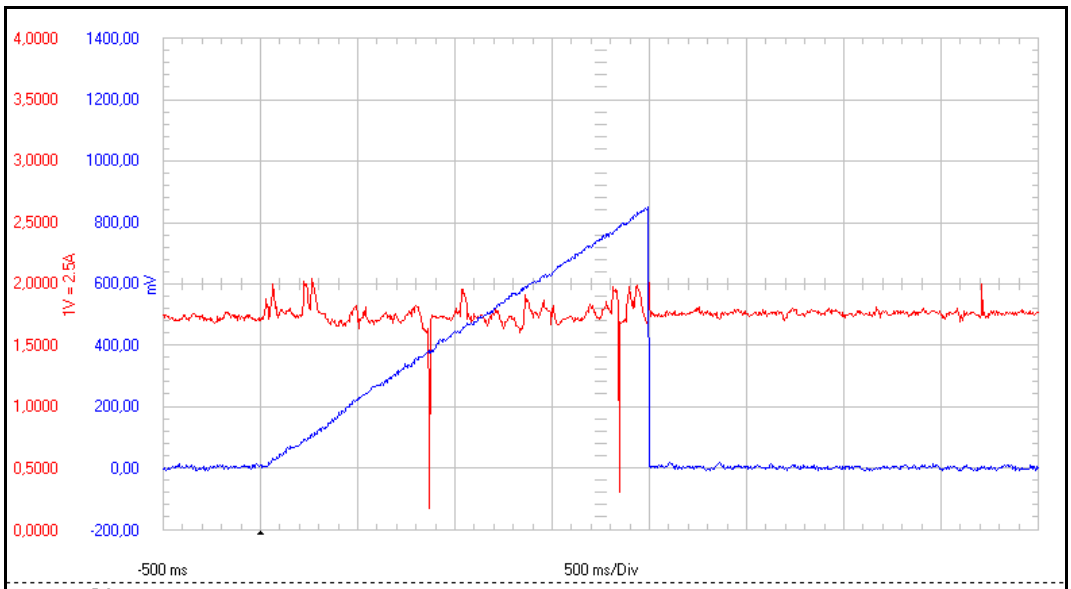
U off density voltage kV dependent (determined by the chamber and screen characteristic)

t corrected see **C eff ht** explanation

number of steps number of calculation steps throughout the set exposure time

time/sample time of a sample step (multiply **number of steps** and **time/sample** = exposure time)

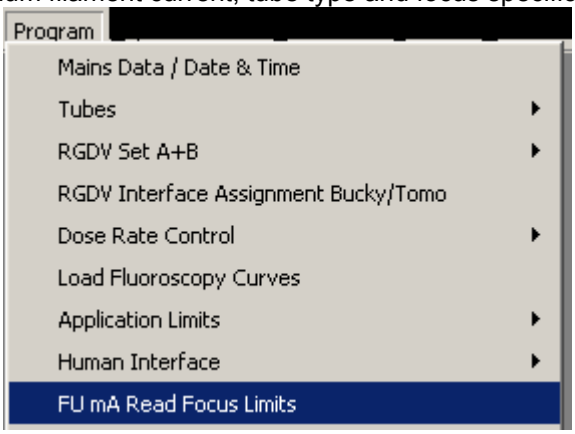
With the initial default APR data set one gets the following dose ramp and filament current curve:

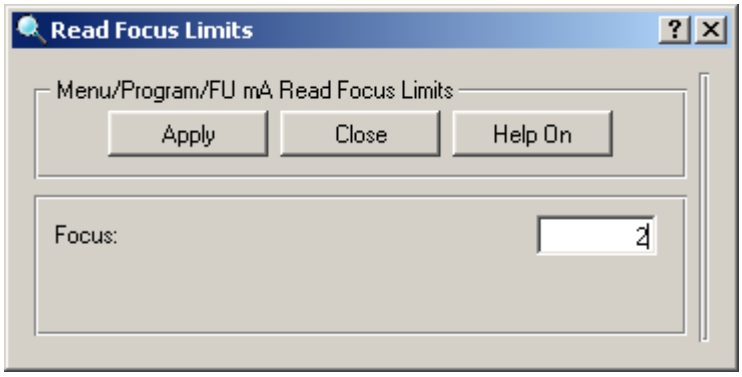



```
TDC-TH01.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
default setting 73kV 32mAs (start mA = 16mA) small focus
U_off = calculated density voltage = 0.785V
1st exposure with default APR data; post indication = 36.4mAs

ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

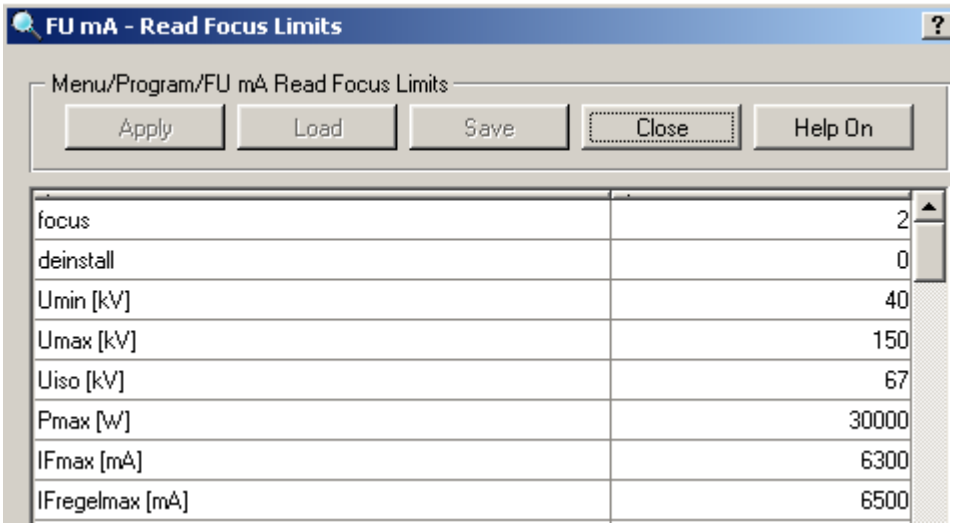
If a deviation of the emission current has to be compensated or if the dose has to be controlled during a TDC exposure the filament control unit uses only two filament current values to achieve the fastest change of the emission current:
- minimum filament current 500mA
- maximum filament current; tube type and focus specific; to see the max value go path:





	tube 1	tube 2	tube 3
large focus	**1**	**3**	**5**
small focus	**2**	**4**	**6**

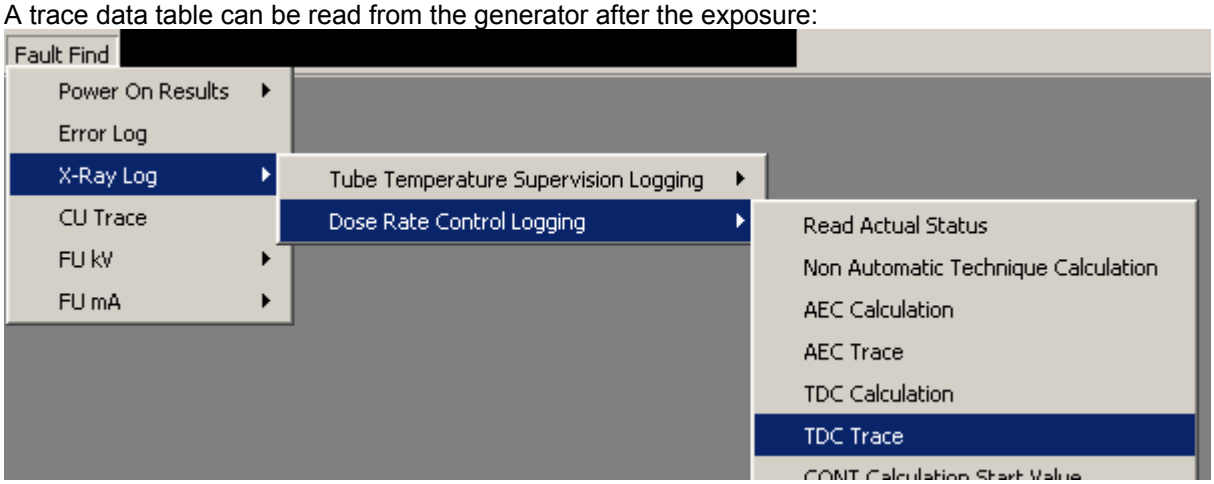
small focus data SRO33100



Ifmax [mA] max filament current for the small focus SRO**33**100
Ifregelmax [mA] offset value to compensate the filament cooling due to the work function; offset value only active during high tension

A perfect TDC exposure is when the dose ramp is a straight line from the exposure start to the density voltage setpoint at the end of the exposure.
A second indication is when the filament current value at the end is the same as in the beginning.
There might of course be a lot of control amplitudes up and down throughout the exposure caused by the non-linear penetration of the exposed region.

A trace data table can be read from the generator after the exposure:



TDC Trace
Fr 11. Mrz 08:05:02 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+1.6000E+1**
2	+1.8E+0	+2	+2.0E+0	+0.0E+0	+1.000E+2	+1.6000E+1
3	+7.4E+0	+5	+3.0E+0	+6.0E-1	+1.081E+2	+1.7296E+1
4	+1.48E+1	+12	+7.0E+0	+1.03E+0	+1.035E+2	+1.7895E+1
5	+2.22E+1	+19	+7.0E+0	+1.18E+0	+1.020E+2	+1.8247E+1
6	+2.96E+1	+27	+8.0E+0	+9.6E-1	+9.96E+1	+1.8167E+1
7	+3.70E+1	+33	+6.0E+0	+2.00E+0	+1.100E+2	+1.9976E+1
8	+4.44E+1	+39	+6.0E+0	+3.45E+0	+1.138E+2	+2.2725E+1
9	+5.19E+1	+47	+8.0E+0	+3.13E+0	+1.003E+2	+2.2788E+1
10	+5.93E+1	+55	+8.0E+0	+2.15E+0	+9.65E+1	+2.1982E+1
11	+6.67E+1	+64	+9.0E+0	+9.9E-1	+9.51E+1	+2.0902E+1
12	+7.41E+1	+74	+1.00E+1	+0.0E+0	+9.55E+1	+1.9959E+1
13	+8.15E+1	+82	+8.0E+0	-5.0E-2	+1.002E+2	+1.9989E+1
14	+8.89E+1	+91	+9.0E+0	-5.2E-1	+9.69E+1	+1.9360E+1
15	+9.63E+1	+99	+8.0E+0	-9.9E-1	+9.65E+1	+1.8682E+1
16	+1.037E+2	+107	+8.0E+0	-1.22E+0	+9.77E+1	+1.8250E+1
17	+1.111E+2	+114	+7.0E+0	-1.07E+0	+1.000E+2	+1.8250E+1
18	+1.185E+2	+121	+7.0E+0	-9.2E-1	+9.99E+1	+1.8231E+1
19	+1.259E+2	+129	+8.0E+0	-1.14E+0	+9.74E+1	+1.7756E+1
20	+1.333E+2	+136	+7.0E+0	-9.9E-1	+1.000E+2	+1.7750E+1
21	+1.408E+2	+143	+7.0E+0	-5.5E-1	+1.021E+2	+1.8122E+1
22	+1.482E+2	+151	+8.0E+0	-1.03E+0	+9.58E+1	+1.7358E+1
23	+1.556E+2	+160	+9.0E+0	-2.20E+0	+9.17E+1	+1.5909E+1
24	+1.630E+2	+167	+7.0E+0	-2.00E+0	+9.99E+1	+1.5884E+1
25	+1.704E+2	+174	+7.0E+0	-1.80E+0	+9.92E+1	+1.5752E+1
26	+1.778E+2	+181	+7.0E+0	-1.18E+0	+1.026E+2	+1.6159E+1
27	+1.852E+2	+186	+5.0E+0	-8.0E-2	+1.080E+2	+1.7442E+1
28	+1.926E+2	+193	+7.0E+0	+0.0E+0	+9.98E+1	+1.7405E+1
29	+2.000E+2	+201	+8.0E+0	-1.0E-1	+9.93E+1	+1.7278E+1
30	+2.074E+2	+209	+8.0E+0	-4.0E-1	+9.79E+1	+1.6907E+1
31	+2.148E+2	+216	+7.0E+0	-1.2E-1	+1.019E+2	+1.7221E+1
32	+2.222E+2	+224	+8.0E+0	-4.5E-1	+9.74E+1	+1.6772E+1
33	+2.297E+2	+232	+8.0E+0	-5.7E-1	+9.90E+1	+1.6602E+1
34	+2.371E+2	+240	+8.0E+0	-1.07E+0	+9.60E+1	+1.5936E+1
35	+2.445E+2	+246	+6.0E+0	-3.7E-1	+1.049E+2	+1.6710E+1
36	+2.519E+2	+252	+6.0E+0	+0.0E+0	+1.021E+2	+1.7060E+1
37	+2.593E+2	+257	+5.0E+0	+5.7E-1	+1.049E+2	+1.7895E+1
38	+2.667E+2	+264	+7.0E+0	+9.9E-1	+1.034E+2	+1.8498E+1
39	+2.741E+2	+272	+8.0E+0	+5.2E-1	+9.75E+1	+1.8027E+1
40	+2.815E+2	+280	+8.0E+0	+3.7E-1	+9.98E+1	+1.7983E+1
41	+2.889E+2	+288	+8.0E+0	+9.0E-2	+9.85E+1	+1.7710E+1
42	+2.963E+2	+296	+8.0E+0	+0.0E+0	+9.97E+1	+1.7656E+1
43	+3.037E+2	+302	+6.0E+0	+4.2E-1	+1.035E+2	+1.8267E+1
44	+3.111E+2	+309	+7.0E+0	+5.2E-1	+1.009E+2	+1.8424E+1
45	+3.186E+2	+316	+7.0E+0	+9.6E-1	+1.038E+2	+1.9119E+1
46	+3.260E+2	+322	+6.0E+0	+2.00E+0	+1.095E+2	+2.0925E+1
47	+3.334E+2	+331	+9.0E+0	+6.0E-1	+9.21E+1	+1.9267E+1
48	+3.408E+2	+338	+7.0E+0	+1.03E+0	+1.049E+2	+2.0203E+1
49	+3.482E+2	+344	+6.0E+0	+2.10E+0	+1.098E+2	+2.2179E+1
50	+3.556E+2	+352	+8.0E+0	+1.80E+0	+9.94E+1	**+2.2036E+1**
51	+3.630E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

Explanation of trace screen columns:
(some values appear as exponential values, e.g.: +2.2036E+1 = 2.2036 x 10^1 = 22.036)

idx index number of step

dose nominal dose setpoint value generated from the **dose calculated** parameter of the TDC calculation screen; typically slightly higher compared to the calculated value

dose actual actual cumulated dose value measured by DRC; identical to oscilloscope dose signal

dose rate actual slope of the dose ramp

reg in internal control signals, no not help for troubleshooting
reg out internal control signals, no not help for troubleshooting

new I new emission current setpoint in [mA], see formula above

Comments to the trace table:

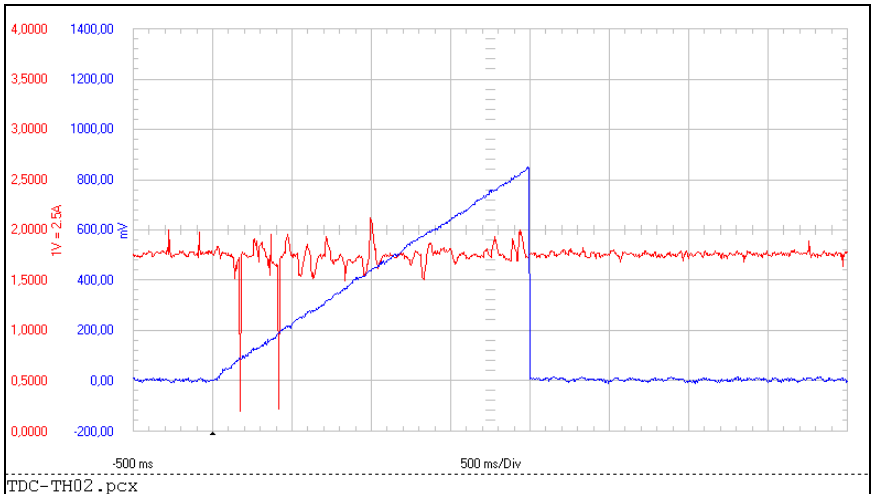
The **new I** column starts with a 16mA emission current, remains almost constant and terminates with an emission current of 22.036mA.
The individual **dose rate** values are more or less identical, which means that the dose ramp slope is almost constant. That's what one can also see on the oscilloscope screenshot TDC-TH01.pcx.

After the first TDC exposure one gets the calculation for the next exposure:

```
TDC Calculation
Fr 11. Mrz 08:05:30 2005

U nominal              : 73 kV
I start                : 22.036 mA
t backup               : 2000 ms
C eff ht               : 4.550 nF
dose measurement input: EZX21
film screen comb.      : 1
dose nominal           : 1 OD
I max                  : 410.958 mA
I min                  : 1 mA
I max NOMO             : 234.109 mA
dose calculated        : 322
kV factor              : 0.960
U off                  : 0.785 V
t corrected            : 1996.226 ms
number of steps        : 49
time/sample            : 40.739 ms
```

The emission current start value **I start** taken from of the previous TDC exposure trace can now be seen.
t corrected increased due to the higher emission current, **time/sample** as well.




```
TDC-TH02.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
73kV  small focus
U_off = calculated density voltage = 0.785V
2nd exposure with start mA = 22.036mA calculated from the previous
exposure 36.4mAs
post indication = 36.5mAs
ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

There is no difference to the first exposure. The post indication mAs value changed from 36.4mAs to 36.5mAs.

TDC Trace
Fr 11. Mrz 08:07:35 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+2.2036E+1**
2	+1.8E+0	+2	+2.0E+0	+0.0E+0	+1.000E+2	+2.2030E+1
3	+7.4E+0	+8	+6.0E+0	-6.0E-2	+9.95E+1	+2.1919E+1
4	+1.48E+1	+16	+8.0E+0	-1.2E-1	+9.96E+1	+2.1822E+1
5	+2.22E+1	+25	+9.0E+0	-1.03E+0	+9.40E+1	+2.0510E+1
6	+2.96E+1	+34	+9.0E+0	-2.20E+0	+9.19E+1	+1.8848E+1
7	+3.70E+1	+41	+7.0E+0	-2.00E+0	+9.99E+1	+1.8821E+1
8	+4.44E+1	+47	+6.0E+0	-9.6E-1	+1.061E+2	+1.9968E+1
9	+5.19E+1	+53	+6.0E+0	-1.1E-1	+1.051E+2	+2.0977E+1
10	+5.93E+1	+61	+8.0E+0	-4.2E-1	+9.72E+1	+2.0382E+1
11	+6.67E+1	+70	+9.0E+0	-1.22E+0	+9.46E+1	+1.9279E+1
12	+7.41E+1	+79	+9.0E+0	-3.13E+0	+8.68E+1	+1.6726E+1
13	+8.15E+1	+85	+6.0E+0	-1.75E+0	+1.092E+2	+1.8258E+1
14	+8.89E+1	+92	+7.0E+0	-1.14E+0	+1.017E+2	+1.8560E+1
15	+9.63E+1	+100	+8.0E+0	-1.85E+0	+9.34E+1	+1.7335E+1
16	+1.037E+2	+107	+7.0E+0	-1.22E+0	+1.032E+2	+1.7884E+1
17	+1.111E+2	+115	+8.0E+0	-1.95E+0	+9.32E+1	+1.6664E+1
18	+1.185E+2	+122	+7.0E+0	-1.75E+0	+9.99E+1	+1.6643E+1
19	+1.259E+2	+128	+6.0E+0	-5.2E-1	+1.080E+2	+1.7971E+1
20	+1.333E+2	+135	+7.0E+0	-4.2E-1	+9.94E+1	+1.7862E+1
21	+1.408E+2	+143	+8.0E+0	-5.5E-1	+9.86E+1	+1.7609E+1
22	+1.482E+2	+151	+8.0E+0	-1.03E+0	+9.62E+1	+1.6931E+1
23	+1.556E+2	+159	+8.0E+0	-1.25E+0	+9.77E+1	+1.6540E+1
24	+1.630E+2	+166	+7.0E+0	-1.11E+0	+9.99E+1	+1.6523E+1
25	+1.704E+2	+174	+8.0E+0	-1.80E+0	+9.39E+1	+1.5512E+1
26	+1.778E+2	+179	+5.0E+0	-1.2E-1	+1.136E+2	+1.7619E+1
27	+1.852E+2	+185	+6.0E+0	+0.0E+0	+9.96E+1	+1.7539E+1
28	+1.926E+2	+193	+8.0E+0	+0.0E+0	+1.000E+2	+1.7530E+1
29	+2.000E+2	+200	+7.0E+0	+0.0E+0	+1.000E+2	+1.7530E+1
30	+2.074E+2	+208	+8.0E+0	-6.0E-2	+9.96E+1	+1.7459E+1
31	+2.148E+2	+216	+8.0E+0	-1.2E-1	+9.96E+1	+1.7380E+1
32	+2.222E+2	+224	+8.0E+0	-4.5E-1	+9.76E+1	+1.6962E+1
33	+2.297E+2	+231	+7.0E+0	-1.3E-1	+1.021E+2	+1.7316E+1
34	+2.371E+2	+240	+9.0E+0	-1.07E+0	+9.35E+1	+1.6184E+1
35	+2.445E+2	+246	+6.0E+0	-3.7E-1	+1.052E+2	+1.7021E+1
36	+2.519E+2	+251	+5.0E+0	+9.0E-2	+1.031E+2	+1.7547E+1
37	+2.593E+2	+257	+6.0E+0	+5.7E-1	+1.037E+2	+1.8188E+1
38	+2.667E+2	+264	+7.0E+0	+9.9E-1	+1.035E+2	+1.8816E+1
39	+2.741E+2	+272	+8.0E+0	+5.2E-1	+9.75E+1	+1.8339E+1
40	+2.815E+2	+280	+8.0E+0	+3.7E-1	+9.98E+1	+1.8293E+1
41	+2.889E+2	+288	+8.0E+0	+9.0E-2	+9.85E+1	+1.8015E+1
42	+2.963E+2	+296	+8.0E+0	+0.0E+0	+9.97E+1	+1.7955E+1
43	+3.037E+2	+303	+7.0E+0	+7.0E-2	+1.006E+2	+1.8057E+1
44	+3.111E+2	+310	+7.0E+0	+1.1E-1	+1.003E+2	+1.8104E+1
45	+3.186E+2	+316	+6.0E+0	+9.6E-1	+1.071E+2	+1.9385E+1
46	+3.260E+2	+323	+7.0E+0	+1.11E+0	+1.016E+2	+1.9690E+1
47	+3.334E+2	+331	+8.0E+0	+6.0E-1	+9.75E+1	+1.9197E+1
48	+3.408E+2	+338	+7.0E+0	+1.03E+0	+1.043E+2	+2.0015E+1
49	+3.482E+2	+344	+6.0E+0	+2.10E+0	+1.098E+2	+2.1970E+1
50	+3.556E+2	+352	+8.0E+0	+1.80E+0	+9.94E+1	**+2.1838E+1**
51	+3.630E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

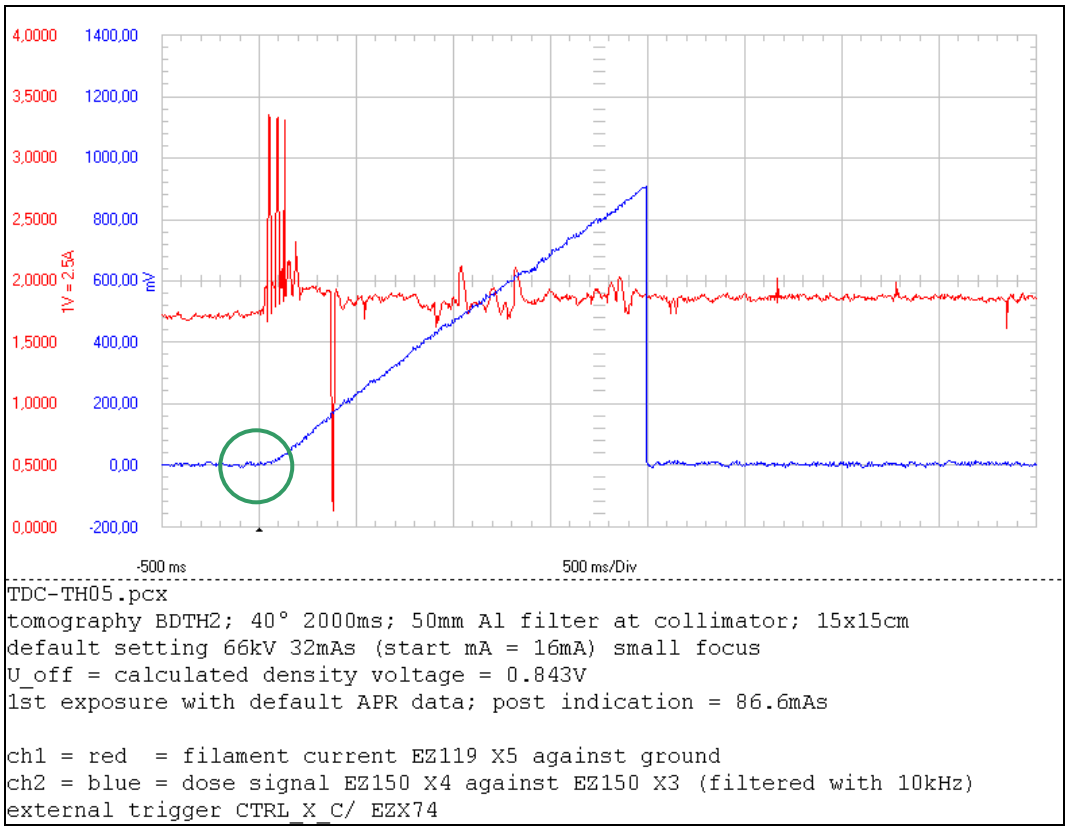
The exposure started with **22.036mA** as predicted, the start value for the next exposure would be **21.838mA**.

The next TDC series was started from the same default APR data set, but now the kV were lowered to 66kV:

```
TDC Calculation
Fr 11. Mrz 08:29:12 2005

U nominal              : 66 kV
I start                : 16 mA
t backup               : 2000 ms
C eff ht               : 4.550 nF
dose measurement input: EZX21
film screen comb.      : 1
dose nominal           : 1 OD
I max                  : 378 mA
I min                  : 1 mA
I max NOMO             : 258.939 mA
dose calculated        : 345
kV factor              : 1.030
U off                  : 0.843 V
t corrected            : 1995.308 ms
number of steps        : 49
time/sample            : 40.720 ms
```

All **bold** marked parameters changed due to the different kV value.




```
TDC-TH05.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
default setting 66kV 32mAs (start mA = 16mA) small focus
U_off = calculated density voltage = 0.843V
1st exposure with default APR data; post indication = 86.6mAs

ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

Since nothing changed in the geometry the dose ramp starts with a little delay (green circle) due to the lower kV with the same attenuator in the beam.
The filament current is instantly increased to its max value at the beginning to increase the emission current and with it the dose.
After about 400ms the filament current remains almost constant for the rest of the exposure. One can see that the filament current at the end of the exposure is higher compared to the start value.

The dose requirement with 86.6mAs was 2.7 times higher at the end compared to the default 32mAs, but the dose ramp is almost linear and the result should have got us a perfect exposure.

In the trace next page one can see what was set during the exposure:

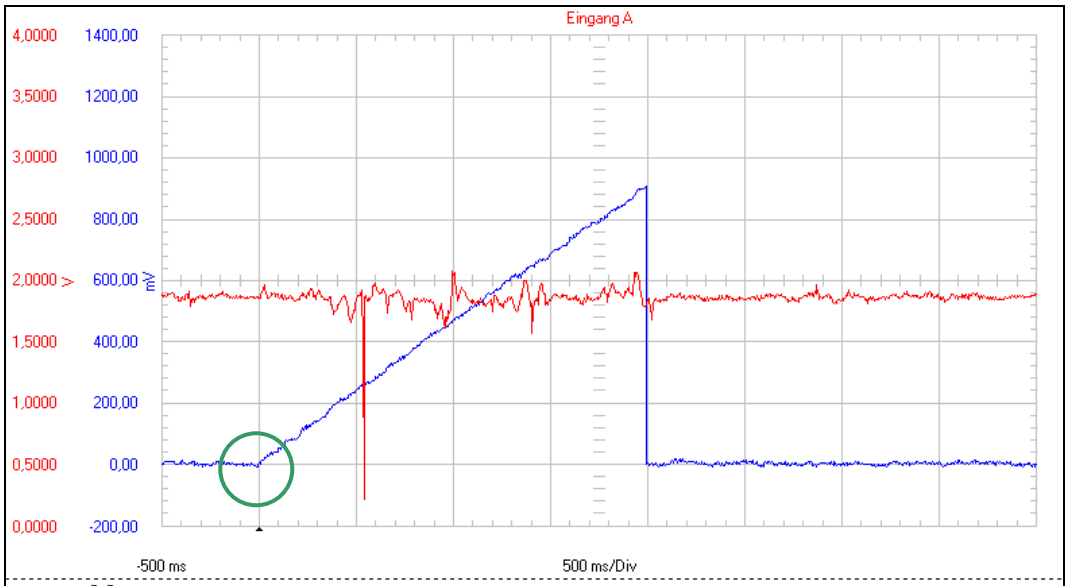
TDC Trace
Fr 11. Mrz 08:30:51 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+1.6000E+1**
2	+1.9E+0	+1	+1.0E+0	+9.0E-2	+1.036E+2	+1.6576E+1
3	+7.9E+0	+3	+2.0E+0	+3.13E+0	+1.465E+2	+2.4275E+1
4	+1.59E+1	+6	+3.0E+0	+9.10E+0	+1.676E+2	+4.0676E+1
5	+2.38E+1	+12	+6.0E+0	+1.144E+1	+1.253E+2	+5.0959E+1
6	+3.18E+1	+20	+8.0E+0	+1.144E+1	+1.099E+2	+5.5994E+1
7	+3.97E+1	+29	+9.0E+0	+1.016E+1	+1.024E+2	+5.7333E+1
8	+4.76E+1	+38	+9.0E+0	+8.83E+0	+1.016E+2	+5.8247E+1
9	+5.56E+1	+47	+9.0E+0	+7.65E+0	+1.014E+2	+5.9055E+1
10	+6.35E+1	+56	+9.0E+0	+6.37E+0	+9.97E+1	+5.8872E+1
11	+7.14E+1	+67	+1.10E+1	+2.20E+0	+8.24E+1	+4.8508E+1
12	+7.94E+1	+77	+1.00E+1	+6.0E-1	+9.47E+1	+4.5929E+1
13	+8.73E+1	+86	+9.0E+0	+1.3E-1	+9.85E+1	+4.5231E+1
14	+9.53E+1	+95	+9.0E+0	+0.0E+0	+9.96E+1	+4.5049E+1
15	+1.032E+2	+104	+9.0E+0	-8.0E-2	+9.96E+1	+4.4859E+1
16	+1.111E+2	+111	+7.0E+0	+0.0E+0	+1.005E+2	+4.5074E+1
17	+1.191E+2	+120	+9.0E+0	-9.0E-2	+9.94E+1	+4.4799E+1
18	+1.270E+2	+127	+7.0E+0	+0.0E+0	+1.006E+2	+4.5058E+1
19	+1.350E+2	+135	+8.0E+0	+0.0E+0	+1.000E+2	+4.5050E+1
20	+1.429E+2	+144	+9.0E+0	-1.1E-1	+9.93E+1	+4.4734E+1
21	+1.508E+2	+152	+8.0E+0	-1.2E-1	+9.99E+1	+4.4685E+1
22	+1.588E+2	+161	+9.0E+0	-5.5E-1	+9.72E+1	+4.3428E+1
23	+1.667E+2	+170	+9.0E+0	-1.22E+0	+9.55E+1	+4.1466E+1
24	+1.747E+2	+179	+9.0E+0	-2.15E+0	+9.34E+1	+3.8723E+1
25	+1.826E+2	+187	+8.0E+0	-2.20E+0	+9.81E+1	+3.7984E+1
26	+1.905E+2	+194	+7.0E+0	-1.75E+0	+1.010E+2	+3.8359E+1
27	+1.985E+2	+199	+5.0E+0	-5.0E-2	+1.124E+2	+4.3105E+1
28	+2.064E+2	+207	+8.0E+0	-6.0E-2	+9.89E+1	+4.2625E+1
29	+2.143E+2	+216	+9.0E+0	-4.2E-1	+9.77E+1	+4.1639E+1
30	+2.223E+2	+225	+9.0E+0	-9.9E-1	+9.62E+1	+4.0048E+1
31	+2.302E+2	+232	+7.0E+0	-4.5E-1	+1.033E+2	+4.1361E+1
32	+2.382E+2	+241	+9.0E+0	-1.03E+0	+9.56E+1	+3.9540E+1
33	+2.461E+2	+250	+9.0E+0	-1.95E+0	+9.35E+1	+3.6969E+1
34	+2.540E+2	+256	+6.0E+0	-5.0E-1	+1.101E+2	+4.0692E+1
35	+2.620E+2	+263	+7.0E+0	-1.0E-1	+1.014E+2	+4.1259E+1
36	+2.699E+2	+270	+7.0E+0	+0.0E+0	+1.003E+2	+4.1373E+1
37	+2.779E+2	+277	+7.0E+0	+9.0E-2	+1.006E+2	+4.1618E+1
38	+2.858E+2	+284	+7.0E+0	+4.5E-1	+1.027E+2	+4.2733E+1
39	+2.937E+2	+292	+8.0E+0	+4.2E-1	+1.000E+2	+4.2730E+1
40	+3.017E+2	+300	+8.0E+0	+4.2E-1	+1.004E+2	+4.2900E+1
41	+3.096E+2	+308	+8.0E+0	+4.0E-1	+1.002E+2	+4.2985E+1
42	+3.176E+2	+317	+9.0E+0	+6.0E-2	+9.83E+1	+4.2249E+1
43	+3.255E+2	+324	+7.0E+0	+3.7E-1	+1.026E+2	+4.3338E+1
44	+3.334E+2	+331	+7.0E+0	+6.0E-1	+1.019E+2	+4.4153E+1
45	+3.414E+2	+339	+8.0E+0	+6.0E-1	+1.004E+2	+4.4326E+1
46	+3.493E+2	+346	+7.0E+0	+1.22E+0	+1.052E+2	+4.6624E+1
47	+3.572E+2	+353	+7.0E+0	+2.10E+0	+1.074E+2	+5.0069E+1
48	+3.652E+2	+362	+9.0E+0	+1.18E+0	+9.56E+1	+4.7857E+1
49	+3.731E+2	+370	+8.0E+0	+1.14E+0	+1.014E+2	+4.8519E+1
50	+3.811E+2	+378	+8.0E+0	+1.14E+0	+1.011E+2	**+4.9043E+1**
51	+3.890E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

Started with **16mA** the exposure the exposure terminated with **49.043mA** which is the start value for the next one.

```
TDC Calculation
Fr 11. Mrz 08:31:29 2005

U nominal              : 66 kV
I start                : 49.043 mA
t backup               : 2000 ms
C eff ht               : 4.550 nF
dose measurement input: EZX21
film screen comb.      : 1
dose nominal           : 1 OD
I max                  : 378 mA
I min                  : 1 mA
I max NOMO             : 258.939 mA
dose calculated        : 345
kV factor              : 1.030
U off                  : 0.843 V
t corrected            : 1998.468 ms
number of steps        : 49
time/sample            : 40.785 ms
```




```
TDC-TH06.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
66kV small focus
U_off = calculated density voltage = 0.843V
2nd exposure with start mA = 49.043mA calculated from the previous
exposure 86.6mAs
post indication = 86.8mAs
ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

Now one can see in the green circle that the dose ramp starts straight from the beginning and has a perfect linear course towards the end. There is almost no control or deviation of the filament current.

Both exposures are almost identical from the load of 86.6mAs (1st) or 86.8mAs (2nd).

The trace next page shows the parameters.

TDC Trace
Fr 11. Mrz 08:32:49 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+4.9043E+1**
2	+1.9E+0	+2	+2.0E+0	+0.0E+0	+1.000E+2	+4.9040E+1
3	+7.9E+0	+8	+6.0E+0	+0.0E+0	+1.000E+2	+4.9040E+1
4	+1.59E+1	+16	+8.0E+0	+0.0E+0	+1.000E+2	+4.9040E+1
5	+2.38E+1	+25	+9.0E+0	-1.2E-1	+9.93E+1	+4.8696E+1
6	+3.18E+1	+34	+9.0E+0	-5.5E-1	+9.73E+1	+4.7375E+1
7	+3.97E+1	+42	+8.0E+0	-5.7E-1	+9.96E+1	+4.7180E+1
8	+4.76E+1	+49	+7.0E+0	-1.4E-1	+1.026E+2	+4.8406E+1
9	+5.56E+1	+56	+7.0E+0	+0.0E+0	+1.005E+2	+4.8642E+1
10	+6.35E+1	+64	+8.0E+0	-5.0E-2	+9.96E+1	+4.8445E+1
11	+7.14E+1	+74	+1.00E+1	-9.6E-1	+9.46E+1	+4.5824E+1
12	+7.94E+1	+82	+8.0E+0	-9.6E-1	+9.97E+1	+4.5682E+1
13	+8.73E+1	+91	+9.0E+0	-1.85E+0	+9.34E+1	+4.2665E+1
14	+9.53E+1	+99	+8.0E+0	-1.85E+0	+9.88E+1	+4.2148E+1
15	+1.032E+2	+108	+9.0E+0	-3.07E+0	+9.05E+1	+3.8136E+1
16	+1.111E+2	+115	+7.0E+0	-1.95E+0	+1.058E+2	+4.0341E+1
17	+1.191E+2	+122	+7.0E+0	-1.07E+0	+1.036E+2	+4.1792E+1
18	+1.270E+2	+129	+7.0E+0	-5.0E-1	+1.024E+2	+4.2792E+1
19	+1.350E+2	+136	+7.0E+0	-1.0E-1	+1.020E+2	+4.3645E+1
20	+1.429E+2	+145	+9.0E+0	-5.2E-1	+9.70E+1	+4.2330E+1
21	+1.508E+2	+153	+8.0E+0	-5.5E-1	+9.96E+1	+4.2160E+1
22	+1.588E+2	+161	+8.0E+0	-5.5E-1	+9.95E+1	+4.1949E+1
23	+1.667E+2	+169	+8.0E+0	-5.7E-1	+9.94E+1	+4.1688E+1
24	+1.747E+2	+178	+9.0E+0	-1.22E+0	+9.54E+1	+3.9762E+1
25	+1.826E+2	+187	+9.0E+0	-2.20E+0	+9.30E+1	+3.6976E+1
26	+1.905E+2	+193	+6.0E+0	-9.2E-1	+1.085E+2	+4.0112E+1
27	+1.985E+2	+199	+6.0E+0	-5.0E-2	+1.050E+2	+4.2115E+1
28	+2.064E+2	+207	+8.0E+0	-6.0E-2	+9.94E+1	+4.1857E+1
29	+2.143E+2	+215	+8.0E+0	-7.0E-2	+9.99E+1	+4.1808E+1
30	+2.223E+2	+224	+9.0E+0	-4.2E-1	+9.78E+1	+4.0880E+1
31	+2.302E+2	+231	+7.0E+0	-8.0E-2	+1.023E+2	+4.1820E+1
32	+2.382E+2	+240	+9.0E+0	-4.5E-1	+9.74E+1	+4.0732E+1
33	+2.461E+2	+248	+8.0E+0	-4.7E-1	+9.97E+1	+4.0607E+1
34	+2.540E+2	+257	+9.0E+0	-1.11E+0	+9.55E+1	+3.8773E+1
35	+2.620E+2	+263	+6.0E+0	-1.0E-1	+1.073E+2	+4.1600E+1
36	+2.699E+2	+270	+7.0E+0	+0.0E+0	+1.000E+2	+4.1600E+1
37	+2.779E+2	+276	+6.0E+0	+4.7E-1	+1.037E+2	+4.3139E+1
38	+2.858E+2	+284	+8.0E+0	+4.5E-1	+1.000E+2	+4.3130E+1
39	+2.937E+2	+292	+8.0E+0	+4.2E-1	+1.002E+2	+4.3216E+1
40	+3.017E+2	+300	+8.0E+0	+4.2E-1	+1.004E+2	+4.3382E+1
41	+3.096E+2	+308	+8.0E+0	+4.0E-1	+1.002E+2	+4.3466E+1
42	+3.176E+2	+317	+9.0E+0	+6.0E-2	+9.83E+1	+4.2721E+1
43	+3.255E+2	+325	+8.0E+0	+5.0E-2	+1.002E+2	+4.2805E+1
44	+3.334E+2	+332	+7.0E+0	+1.4E-1	+1.007E+2	+4.3099E+1
45	+3.414E+2	+339	+7.0E+0	+6.0E-1	+1.035E+2	+4.4598E+1
46	+3.493E+2	+346	+7.0E+0	+1.22E+0	+1.049E+2	+4.6774E+1
47	+3.572E+2	+354	+8.0E+0	+1.18E+0	+1.005E+2	+4.7003E+1
48	+3.652E+2	+362	+8.0E+0	+1.18E+0	+1.012E+2	+4.7564E+1
49	+3.731E+2	+369	+7.0E+0	+2.05E+0	+1.077E+2	+5.1222E+1
50	+3.811E+2	+378	+9.0E+0	+1.14E+0	+9.56E+1	**+4.8966E+1**
51	+3.890E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

Started with 49.043mA the exposure ended with 48.966mA, start point for the next sweep if required.

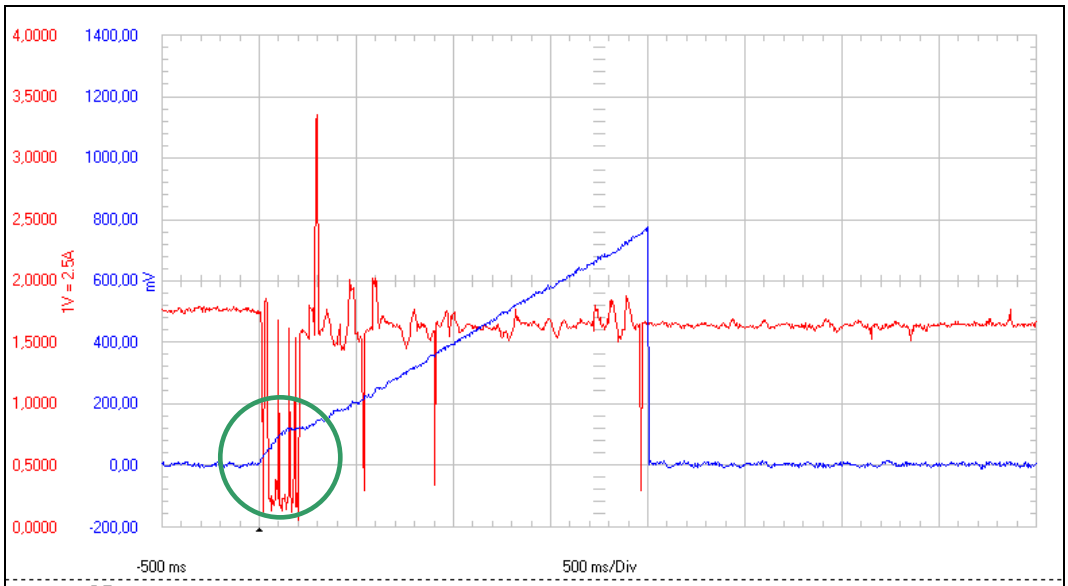
New tomo series start:

The system parameters are still the same:
110cm SID, 15x15cm format, 40° 2000ms, 50mm Al filter at collimator.

Exposure data were changed to monitor what happens if the initial APR settings do not match with the "organ" or attenuator. New settings: 81kV 50mAs.

```
TDC Calculation
Fr 11. Mrz 08:33:57 2005

U nominal              : 81 kV
I start                : 25 mA
t backup               : 2000 ms
C eff ht               : 4.550 nF
dose measurement input: EZX21
film screen comb.      : 1
dose nominal           : 1 OD
I max                  : 370.370 mA
I min                  : 1 mA
I max NOMO             : 210.987 mA
dose calculated        : 291
kV factor              : 0.870
U off                  : 0.712 V
t corrected            : 1996.315 ms
number of steps        : 49
time/sample            : 40.741 ms
```




```
TDC-TH07.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
default setting 81kV 50mAs (start mA = 25mA) small focus
U_off = calculated density voltage = 0.712V
1st exposure with default APR data; post indication = 16.5mAs

ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

The start mA value is too high. The dose signal rises very quickly (green circle).
With constant 25mA the density voltage would be achieved in less than a second.
TDC instantly reacts by decreasing the filament current.
A constant value is found at 300…400ms, then the dose ramp is constant and linear throughout the rest of the sweep.

In the trace table next page one can see the set values.

TDC Trace
Fr 11. Mrz 08:35:22 2005

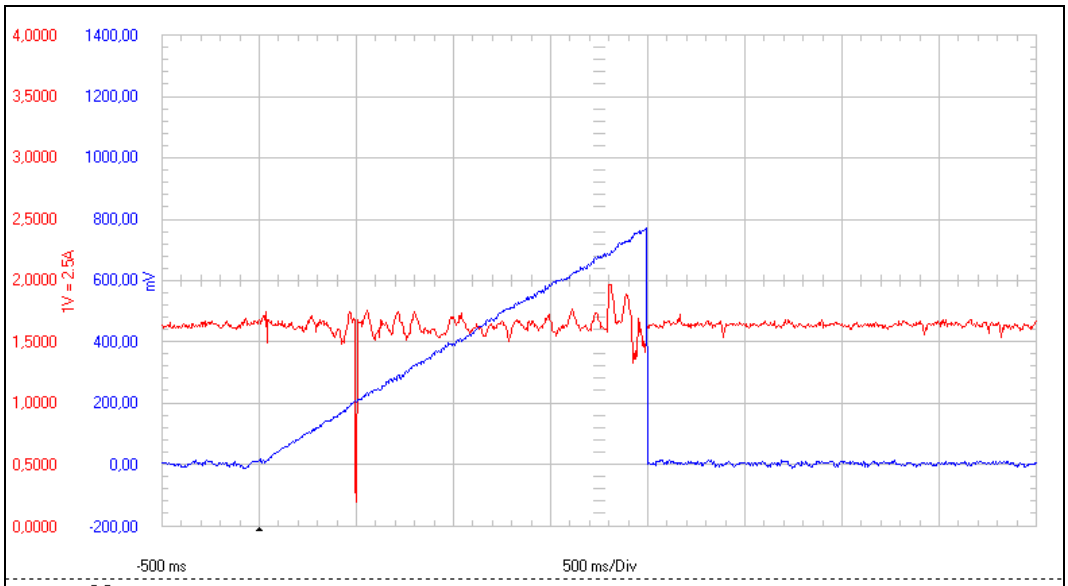
idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+2.5000E+1**
2	+1.6E+0	+4	+4.0E+0	-6.0E-1	+8.92E+1	+2.2300E+1
3	+6.7E+0	+18	+1.40E+1	-1.073E+1	+5.00E+1	+1.1150E+1
4	+1.34E+1	+33	+1.50E+1	-1.960E+1	+5.53E+1	+6.165E+0
5	+2.01E+1	+41	+8.0E+0	-2.090E+1	+7.55E+1	+4.650E+0
6	+2.68E+1	+47	+6.0E+0	-2.020E+1	+8.06E+1	+3.747E+0
7	+3.35E+1	+51	+4.0E+0	-1.750E+1	+9.68E+1	+3.620E+0
8	+4.02E+1	+54	+3.0E+0	-1.380E+1	+1.111E+2	+4.021E+0
9	+4.69E+1	+55	+1.0E+0	-6.88E+0	+1.767E+2	+7.103E+0
10	+5.36E+1	+60	+5.0E+0	-4.67E+0	+1.056E+2	+7.497E+0
11	+6.02E+1	+66	+6.0E+0	-4.23E+0	+9.62E+1	+7.205E+0
12	+6.69E+1	+73	+7.0E+0	-4.45E+0	+9.31E+1	+6.703E+0
13	+7.36E+1	+78	+5.0E+0	-2.20E+0	+1.157E+2	+7.751E+0
14	+8.03E+1	+84	+6.0E+0	-1.85E+0	+9.85E+1	+7.633E+0
15	+8.70E+1	+92	+8.0E+0	-3.20E+0	+8.79E+1	+6.706E+0
16	+9.37E+1	+97	+5.0E+0	-1.22E+0	+1.158E+2	+7.758E+0
17	+1.004E+2	+102	+5.0E+0	-4.0E-1	+1.044E+2	+8.091E+0
18	+1.071E+2	+108	+6.0E+0	-9.0E-2	+1.015E+2	+8.211E+0
19	+1.138E+2	+115	+7.0E+0	-1.2E-1	+9.95E+1	+8.168E+0
20	+1.205E+2	+123	+8.0E+0	-9.2E-1	+9.41E+1	+7.678E+0
21	+1.272E+2	+129	+6.0E+0	-4.5E-1	+1.035E+2	+7.938E+0
22	+1.339E+2	+135	+6.0E+0	-1.1E-1	+1.020E+2	+8.088E+0
23	+1.406E+2	+143	+8.0E+0	-6.0E-1	+9.61E+1	+7.764E+0
24	+1.473E+2	+151	+8.0E+0	-1.85E+0	+9.05E+1	+7.022E+0
25	+1.540E+2	+157	+6.0E+0	-1.11E+0	+1.051E+2	+7.378E+0
26	+1.607E+2	+162	+5.0E+0	-1.3E-1	+1.072E+2	+7.900E+0
27	+1.673E+2	+167	+5.0E+0	+0.0E+0	+1.002E+2	+7.915E+0
28	+1.740E+2	+174	+7.0E+0	+0.0E+0	+1.000E+2	+7.910E+0
29	+1.807E+2	+181	+7.0E+0	+0.0E+0	+1.000E+2	+7.910E+0
30	+1.874E+2	+188	+7.0E+0	-6.0E-2	+9.96E+1	+7.878E+0
31	+1.941E+2	+195	+7.0E+0	-9.0E-2	+9.98E+1	+7.854E+0
32	+2.008E+2	+203	+8.0E+0	-5.5E-1	+9.66E+1	+7.583E+0
33	+2.075E+2	+210	+7.0E+0	-9.2E-1	+9.68E+1	+7.337E+0
34	+2.142E+2	+216	+6.0E+0	-4.5E-1	+1.032E+2	+7.564E+0
35	+2.209E+2	+222	+6.0E+0	-1.1E-1	+1.020E+2	+7.711E+0
36	+2.276E+2	+227	+5.0E+0	+6.0E-2	+1.011E+2	+7.794E+0
37	+2.343E+2	+233	+6.0E+0	+1.3E-1	+1.005E+2	+7.828E+0
38	+2.410E+2	+239	+6.0E+0	+5.0E-1	+1.033E+2	+8.078E+0
39	+2.477E+2	+247	+8.0E+0	+7.0E-2	+9.72E+1	+7.844E+0
40	+2.544E+2	+253	+6.0E+0	+1.4E-1	+1.010E+2	+7.918E+0
41	+2.611E+2	+260	+7.0E+0	+1.1E-1	+9.99E+1	+7.902E+0
42	+2.678E+2	+266	+6.0E+0	+4.5E-1	+1.031E+2	+8.144E+0
43	+2.744E+2	+272	+6.0E+0	+6.0E-1	+1.016E+2	+8.270E+0
44	+2.811E+2	+278	+6.0E+0	+1.14E+0	+1.053E+2	+8.708E+0
45	+2.878E+2	+285	+7.0E+0	+1.03E+0	+1.000E+2	+8.700E+0
46	+2.945E+2	+291	+6.0E+0	+1.75E+0	+1.077E+2	+9.369E+0
47	+3.012E+2	+298	+7.0E+0	+1.18E+0	+9.70E+1	+9.079E+0
48	+3.079E+2	+304	+6.0E+0	+1.95E+0	+1.087E+2	+9.859E+0
49	+3.146E+2	+311	+7.0E+0	+1.80E+0	+1.005E+2	+9.899E+0
50	+3.213E+2	+319	+8.0E+0	+5.7E-1	+9.30E+1	**+9.197E+0**
51	+3.280E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

From the 9th **idx** step onwards one gets an almost constant average mA value,
Ignoring step zero of the table the time can be calculated:
(**idx** steps) x (time/sample) = 8 x 40.741 = 326ms, which matches with the chamber dose signal on the oscilloscope screenshot.

The follwing exposure will be started with the last mA value of this exposure = 9.197mA.

TDC Calculation
Fr 11. Mrz 08:36:10 2005

U nominal : 81 kV
I start : **9.197 mA**
t backup : 2000 ms
C eff ht : 4.550 nF
dose measurement input: EZX21
film screen comb. : 1
dose nominal : 1 OD
I max : 370.370 mA
I min : 1 mA
I max NOMO : 210.987 mA
dose calculated : 291
kV factor : 0.870
U off : 0.712 V
t corrected : **1989.875 ms**
number of steps : 49
time/sample : **40.609 ms**



TDC-TH08.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
81kV small focus
U_off = calculated density voltage = 0.712V
2nd exposure with start mA = 9.197mA calculated from the previous exposure 16.5mAs
post indication = 16.7mAs
ch1 = red = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74

The dose ramp starts straight from the beginning and has is linear throughout the rest of the sweep.

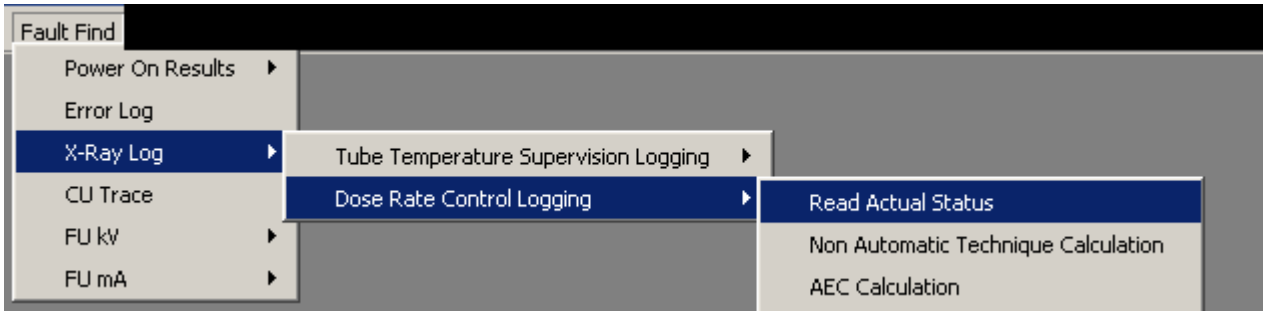
The filament current is almost constant and ends where it started, the trace table next page starts with 9.197mA and ends with 9.321mA.

TDC Trace
Fr 11. Mrz 08:38:10 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+9.197E+0**
2	+1.6E+0	+2	+2.0E+0	+0.0E+0	+1.000E+2	+9.190E+0
3	+6.7E+0	+7	+5.0E+0	+0.0E+0	+1.000E+2	+9.190E+0
4	+1.34E+1	+14	+7.0E+0	-6.0E-2	+9.96E+1	+9.153E+0
5	+2.01E+1	+21	+7.0E+0	-9.0E-2	+9.98E+1	+9.131E+0
6	+2.68E+1	+28	+7.0E+0	-1.2E-1	+9.97E+1	+9.102E+0
7	+3.35E+1	+35	+7.0E+0	-3.7E-1	+9.79E+1	+8.908E+0
8	+4.02E+1	+41	+6.0E+0	-8.0E-2	+1.022E+2	+9.095E+0
9	+4.69E+1	+47	+6.0E+0	+0.0E+0	+1.003E+2	+9.117E+0
10	+5.36E+1	+54	+7.0E+0	+0.0E+0	+1.000E+2	+9.110E+0
11	+6.02E+1	+62	+8.0E+0	-4.5E-1	+9.67E+1	+8.809E+0
12	+6.69E+1	+70	+8.0E+0	-1.14E+0	+9.48E+1	+8.342E+0
13	+7.36E+1	+76	+6.0E+0	-6.0E-1	+1.038E+2	+8.656E+0
14	+8.03E+1	+84	+8.0E+0	-1.85E+0	+8.99E+1	+7.776E+0
15	+8.70E+1	+90	+6.0E+0	-1.11E+0	+1.051E+2	+8.166E+0
16	+9.37E+1	+97	+7.0E+0	-1.22E+0	+9.73E+1	+7.939E+0
17	+1.004E+2	+103	+6.0E+0	-9.6E-1	+1.008E+2	+7.993E+0
18	+1.071E+2	+110	+7.0E+0	-1.07E+0	+9.79E+1	+7.822E+0
19	+1.138E+2	+116	+6.0E+0	-5.5E-1	+1.032E+2	+8.070E+0
20	+1.205E+2	+123	+7.0E+0	-9.2E-1	+9.61E+1	+7.755E+0
21	+1.272E+2	+129	+6.0E+0	-4.5E-1	+1.032E+2	+7.998E+0
22	+1.339E+2	+136	+7.0E+0	-5.2E-1	+9.86E+1	+7.878E+0
23	+1.406E+2	+143	+7.0E+0	-6.0E-1	+9.89E+1	+7.783E+0
24	+1.473E+2	+150	+7.0E+0	-9.9E-1	+9.63E+1	+7.492E+0
25	+1.540E+2	+157	+7.0E+0	-1.11E+0	+9.82E+1	+7.355E+0
26	+1.607E+2	+163	+6.0E+0	-5.7E-1	+1.034E+2	+7.599E+0
27	+1.673E+2	+167	+4.0E+0	+0.0E+0	+1.047E+2	+7.946E+0
28	+1.740E+2	+175	+8.0E+0	-1.0E-1	+9.89E+1	+7.852E+0
29	+1.807E+2	+181	+6.0E+0	+0.0E+0	+1.008E+2	+7.912E+0
30	+1.874E+2	+189	+8.0E+0	-4.0E-1	+9.70E+1	+7.672E+0
31	+1.941E+2	+196	+7.0E+0	-4.7E-1	+9.93E+1	+7.616E+0
32	+2.008E+2	+202	+6.0E+0	-1.2E-1	+1.025E+2	+7.800E+0
33	+2.075E+2	+209	+7.0E+0	-3.7E-1	+9.77E+1	+7.620E+0
34	+2.142E+2	+215	+6.0E+0	-8.0E-2	+1.022E+2	+7.787E+0
35	+2.209E+2	+222	+7.0E+0	-1.1E-1	+9.95E+1	+7.741E+0
36	+2.276E+2	+227	+5.0E+0	+6.0E-2	+1.015E+2	+7.856E+0
37	+2.343E+2	+233	+6.0E+0	+1.3E-1	+1.005E+2	+7.889E+0
38	+2.410E+2	+239	+6.0E+0	+5.0E-1	+1.033E+2	+8.140E+0
39	+2.477E+2	+247	+8.0E+0	+7.0E-2	+9.72E+1	+7.912E+0
40	+2.544E+2	+254	+7.0E+0	+0.0E+0	+9.99E+1	+7.902E+0
41	+2.611E+2	+259	+5.0E+0	+5.2E-1	+1.050E+2	+8.295E+0
42	+2.678E+2	+266	+7.0E+0	+4.5E-1	+9.97E+1	+8.265E+0
43	+2.744E+2	+273	+7.0E+0	+1.4E-1	+9.81E+1	+8.103E+0
44	+2.811E+2	+279	+6.0E+0	+5.2E-1	+1.037E+2	+8.399E+0
45	+2.878E+2	+286	+7.0E+0	+4.5E-1	+9.98E+1	+8.373E+0
46	+2.945E+2	+291	+5.0E+0	+1.75E+0	+1.132E+2	+9.474E+0
47	+3.012E+2	+297	+6.0E+0	+2.10E+0	+1.042E+2	+9.867E+0
48	+3.079E+2	+303	+6.0E+0	+3.13E+0	+1.114E+2	+1.0984E+1
49	+3.146E+2	+311	+8.0E+0	+1.80E+0	+9.29E+1	+1.0200E+1
50	+3.213E+2	+319	+8.0E+0	+5.7E-1	+9.38E+1	+9.567E+0
51	+3.280E+2	+328	+9.0E+0	+0.0E+0	+9.75E+1	**+9.321E+0**
52	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

To check whether the CTRL_X/ signal was active throughout the selected exposure time one can see it indirectly reading the exposure time logged by the generator.

The screen



has the following information:

```
Read Actual Status
Fr 11. Mrz 08:38:57 2005

selected mode                    : TDC
time measured                    : 1999.511 ms
last I                           : 9.321 mA
last U                           : 81 kV
dose relative                    : 100.300 %
dose offset                      :  0
last dose measured               :  0
detected spikes                  : 0
LOCK IN state                    : UNLOCK
DRL (dose rate limitation) state: OFF
```

One can see the selected technique and the exposure time, which is measured between 75% of the set kV when it rises and 75% of the kV when it falls.

The prediction of the calculation screen was a little shorter, but it is related to the start mA.

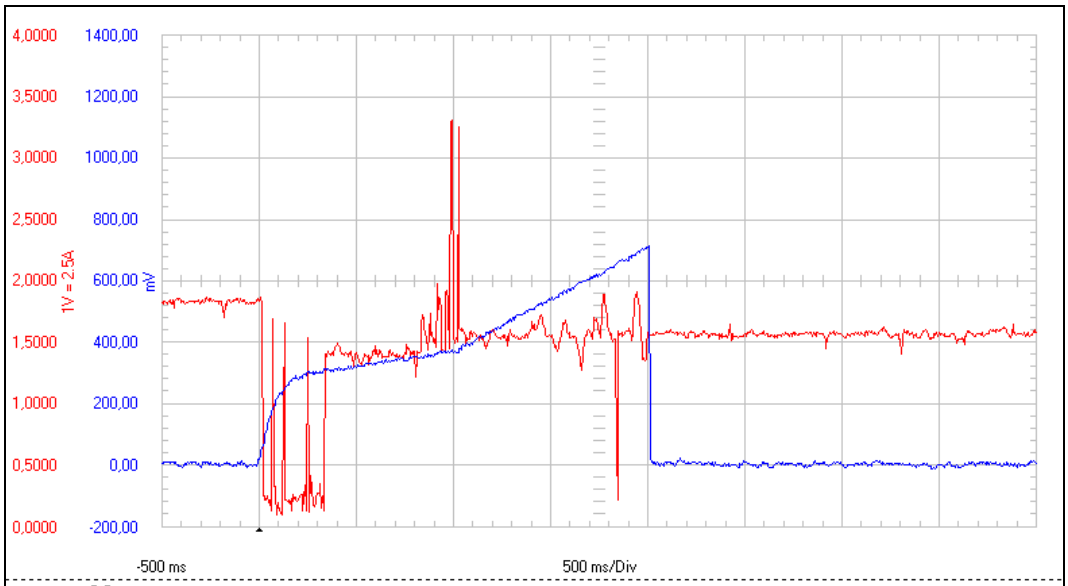
To detect problems with the tomo geometry of any kind the RGDV Dats Sets A should always have

so that the generator can turn the underexposure light on when the geometry exposure command CTRL_X/ via the signal bus
or
CTRL_X/ via a release circuit adaptation unit WA/WB
was too short.

The last TDC test was made with the same conditions as the one before, but with a higher kV = 90kV as well with a higher start mA value of 40mA.

```
TDC Calculation
Fr 11. Mrz 08:40:31 2005

U nominal              : 90 kV
I start                : 40 mA
t backup               : 2000 ms
C eff ht               : 4.550 nF
dose measurement input: EZX21
film screen comb.      : 1
dose nominal           : 1 OD
I max                  : 333.333 mA
I min                  : 1 mA
I max NOMO             : 189.888 mA
dose calculated        : 271
kV factor              : 0.810
U off                  : 0.662 V
t corrected            : 1997.441 ms
number of steps        : 49
time/sample            : 40.764 ms
```




```
TDC-TH09.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
default setting 90kV 80mAs (start mA = 40mA) small focus
U_off = calculated density voltage = 0.662V
1st exposure with default APR data; post indication = 8.83mAs

ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

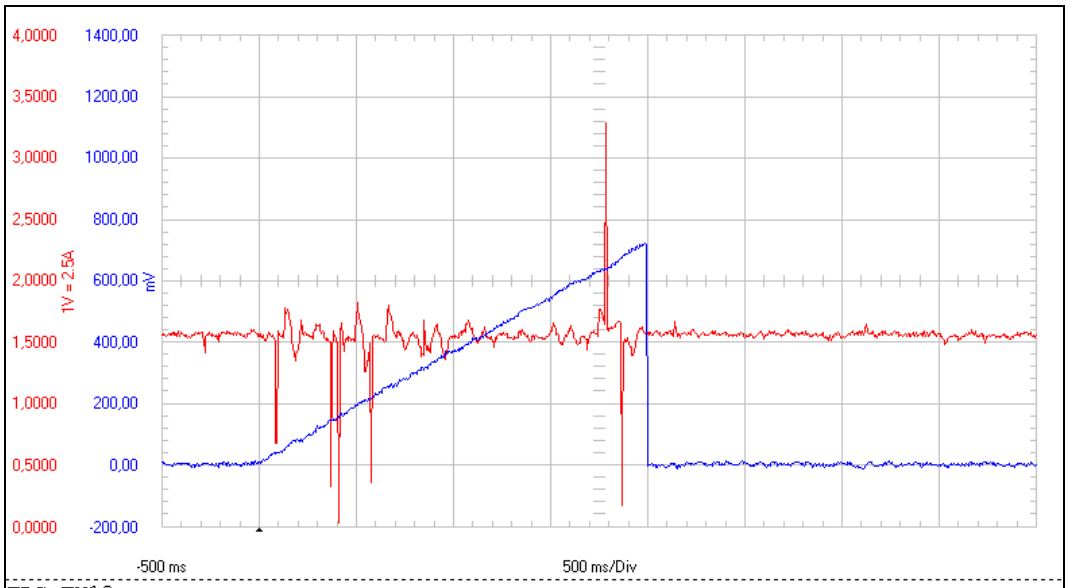
This will not be a good tomo exposure from the resolution point of view.
Almost 40% of the density is already achieved after about 200ms of 2000ms total time.
For about 350ms the filament current is off to decrease the filament temperature as fast as possible.

After 50% of the exposure time the filament current increases again with a 100ms filament max heat-up phase to find a constant ramp to the final density voltage value.

TDC Trace
Fr 11. Mrz 08:41:52 2005

idx	dose nominal	dose actual	dose rate	reg in	reg out	new I
0	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0
1	+0.0E+0	+0	+0.0E+0	+0.0E+0	+0.0E+0	**+4.0000E+1**
2	+1.5E+0	+13	+1.30E+1	-1.115E+1	+5.00E+1	+2.0000E+1
3	+6.2E+0	+50	+3.70E+1	-4.380E+1	+5.00E+1	+1.0000E+1
4	+1.24E+1	+81	+3.10E+1	-6.860E+1	+5.00E+1	+5.000E+0
5	+1.87E+1	+101	+2.00E+1	-8.230E+1	+5.00E+1	+2.500E+0
6	+2.49E+1	+114	+1.30E+1	-8.910E+1	+5.00E+1	+1.250E+0
7	+3.11E+1	+121	+7.0E+0	-8.990E+1	+5.00E+1	+1.000E+0
8	+3.73E+1	+125	+4.0E+0	-8.770E+1	+5.00E+1	+1.000E+0
9	+4.36E+1	+128	+3.0E+0	-8.440E+1	+5.00E+1	+1.000E+0
10	+4.98E+1	+129	+1.0E+0	-7.920E+1	+5.00E+1	+1.000E+0
11	+5.60E+1	+131	+2.0E+0	-7.500E+1	+5.00E+1	+1.000E+0
12	+6.22E+1	+133	+2.0E+0	-7.080E+1	+5.00E+1	+1.000E+0
13	+6.85E+1	+134	+1.0E+0	-6.550E+1	+5.00E+1	+1.000E+0
14	+7.47E+1	+135	+1.0E+0	-6.030E+1	+5.00E+1	+1.000E+0
15	+8.09E+1	+138	+3.0E+0	-5.710E+1	+5.00E+1	+1.000E+0
16	+8.71E+1	+138	+0.0E+0	-5.090E+1	+5.00E+1	+1.000E+0
17	+9.34E+1	+140	+2.0E+0	-4.660E+1	+5.00E+1	+1.000E+0
18	+9.96E+1	+141	+1.0E+0	-4.140E+1	+6.49E+1	+1.000E+0
19	+1.058E+2	+143	+2.0E+0	-3.720E+1	+6.58E+1	+1.000E+0
20	+1.120E+2	+145	+2.0E+0	-3.300E+1	+7.62E+1	+1.000E+0
21	+1.183E+2	+146	+1.0E+0	-2.770E+1	+1.020E+2	+1.020E+0
22	+1.245E+2	+147	+1.0E+0	-2.250E+1	+1.123E+2	+1.145E+0
23	+1.307E+2	+149	+2.0E+0	-1.830E+1	+1.067E+2	+1.216E+0
24	+1.369E+2	+151	+2.0E+0	-1.410E+1	+1.172E+2	+1.418E+0
25	+1.432E+2	+154	+3.0E+0	-1.026E+1	+1.179E+2	+1.662E+0
26	+1.494E+2	+155	+1.0E+0	-4.08E+0	+1.774E+2	+2.944E+0
27	+1.556E+2	+158	+3.0E+0	-6.0E-1	+1.298E+2	+3.816E+0
28	+1.618E+2	+163	+5.0E+0	-1.2E-1	+1.007E+2	+3.836E+0
29	+1.681E+2	+169	+6.0E+0	-9.0E-2	+9.98E+1	+3.822E+0
30	+1.743E+2	+176	+7.0E+0	-4.2E-1	+9.72E+1	+3.713E+0
31	+1.805E+2	+181	+5.0E+0	-5.0E-2	+1.034E+2	+3.836E+0
32	+1.867E+2	+188	+7.0E+0	-1.3E-1	+9.91E+1	+3.795E+0
33	+1.930E+2	+194	+6.0E+0	-1.0E-1	+1.001E+2	+3.793E+0
34	+1.992E+2	+200	+6.0E+0	-8.0E-2	+1.000E+2	+3.790E+0
35	+2.054E+2	+205	+5.0E+0	+0.0E+0	+1.006E+2	+3.812E+0
36	+2.116E+2	+210	+5.0E+0	+4.0E-1	+1.039E+2	+3.958E+0
37	+2.179E+2	+215	+5.0E+0	+1.07E+0	+1.068E+2	+4.218E+0
38	+2.241E+2	+221	+6.0E+0	+1.14E+0	+1.014E+2	+4.268E+0
39	+2.303E+2	+228	+7.0E+0	+5.7E-1	+9.67E+1	+4.119E+0
40	+2.365E+2	+234	+6.0E+0	+9.2E-1	+1.043E+2	+4.286E+0
41	+2.428E+2	+240	+6.0E+0	+1.03E+0	+1.019E+2	+4.361E+0
42	+2.490E+2	+248	+8.0E+0	+1.0E-1	+9.41E+1	+4.102E+0
43	+2.552E+2	+254	+6.0E+0	+1.2E-1	+1.010E+2	+4.141E+0
44	+2.614E+2	+259	+5.0E+0	+6.0E-1	+1.049E+2	+4.342E+0
45	+2.677E+2	+264	+5.0E+0	+1.85E+0	+1.128E+2	+4.895E+0
46	+2.739E+2	+270	+6.0E+0	+1.95E+0	+1.023E+2	+5.002E+0
47	+2.801E+2	+278	+8.0E+0	+5.2E-1	+9.13E+1	+4.565E+0
48	+2.863E+2	+284	+6.0E+0	+5.7E-1	+1.023E+2	+4.664E+0
49	+2.926E+2	+289	+5.0E+0	+1.80E+0	+1.130E+2	+5.265E+0
50	+2.988E+2	+296	+7.0E+0	+1.03E+0	+9.49E+1	**+4.991E+0**
51	+3.050E+2	+0	+0.0E+0	+0.0E+0	+0.0E+0	+0.0E+0

The final emission current setpoint of the TDC trace is the start value for the next exposure.
The calculation screen was lost, but the oscilloscope screenshot next page shows a perfect dose ramp.




```
TDC-TH10.pcx
tomography BDTH2; 40° 2000ms; 50mm Al filter at collimator; 15x15cm
90kV 80mAs small focus
U_off = calculated density voltage = 0.662V
2nd exposure with start mA = (sorry, data lost) from previous 8.83mAs
post indication = 8.68mAs
ch1 = red  = filament current EZ119 X5 against ground
ch2 = blue = dose signal EZ150 X4 against EZ150 X3 (filtered with 10kHz)
external trigger CTRL_X_C/ EZX74
```

mAs value of the first sweep with start values way too high and the mAs of the 2nd exposure are very close.

```
Read Actual Status
Fr 11. Mrz 08:43:41 2005

selected mode                    : TDC
time measured                    : 1999.405 ms
last I                           : 4.820 mA
last U                           : 90 kV
dose relative                    : 100.900 %
dose offset                      :  1
last dose measured               :  0
detected spikes                  : 0
LOCK IN state                    : UNLOCK
DRL (dose rate limitation) state: OFF
```

The exposure time is correct, no problems with the hardware release signals.